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Experimental validation of a Bulk Built-In Current Sensor for detecting laser-induced current

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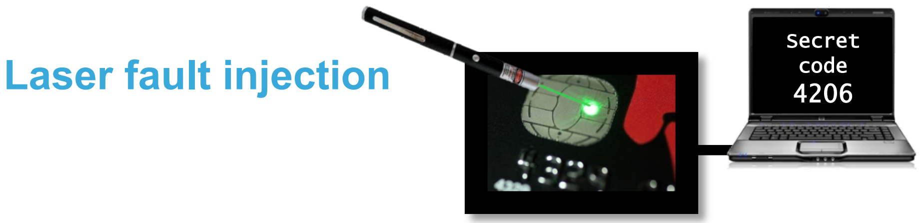
Introduction

- Laser fault injection may be used to **alter a behavior** of an integrated circuit (IC)
  - e.g. **retrieve/modify** secret data in integrated circuit



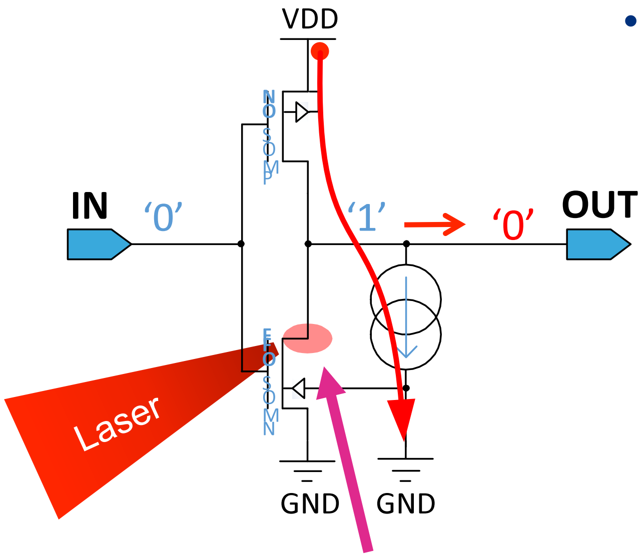
- Sensors are used to catch and flag when a perturbation appears

- **B**ulk **B**uilt-**I**n **C**urrent **S**ensors (**BBICS**) were developed to detect the transient bulk currents induced in the bulk of ICs

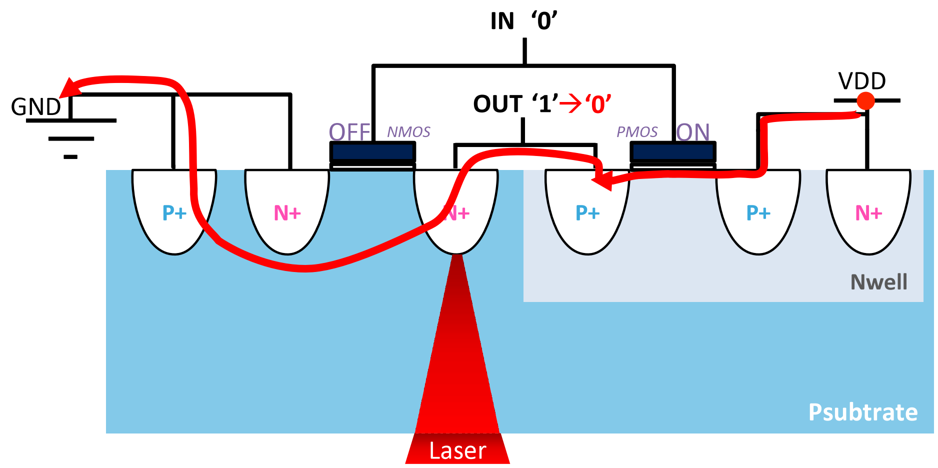
- This presentation reports the experimental evaluation of a complete **BBICS architecture**, designed to simultaneously monitor **PMOS and NMOS wells**, under Photoelectric Laser Stimulation (**PLS**)

Single-Events Effects (SEE)

- Example: Laser effect on a **CMOS inverter** with its input at low level
  - Photocurrent flows **through the Psubstrate**
  - Sensitive junction is the **Drain** of NMOS which is in OFF state



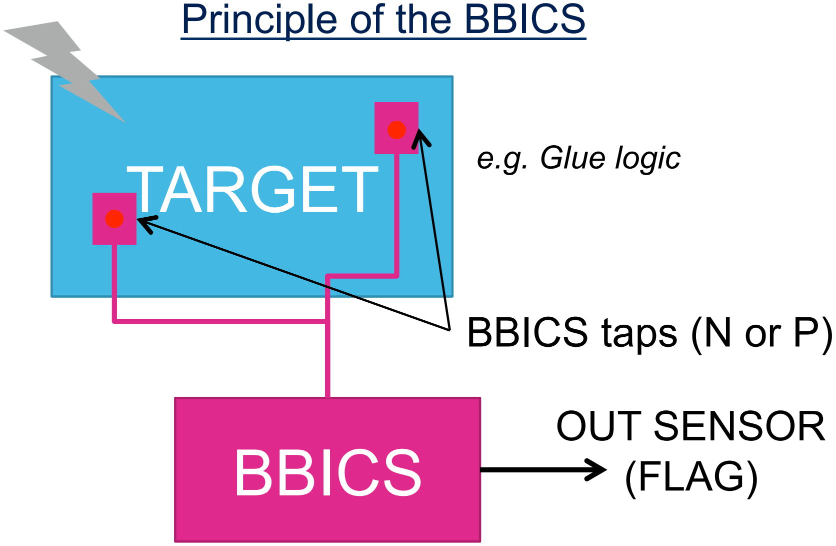
- State of the output **from '1' to '0'**
  - **Stuck-at fault**



BBICS principles

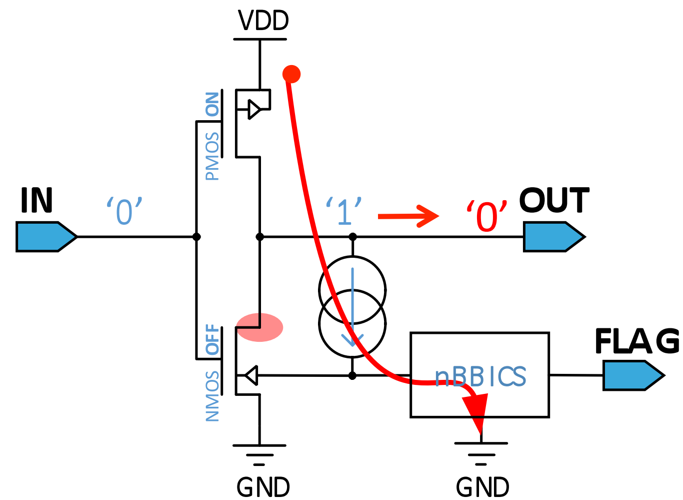
- **BBICS** stands for **B**ulk **B**uilt-**I**n **C**urrent **S**ensor
  - Principle : The BBICS detect all single-event transient currents in a target thanks to its different biasing taps in a target.

Principle of the BBICS



- BBICS **bias** the target
- BBICS **detect** the photocurrent flowing the BBICS taps

nBBICS principle



- Psubstrate **biased** thought the nBBICS
- nBBICS **detects** the photocurrent flowing in the sensor

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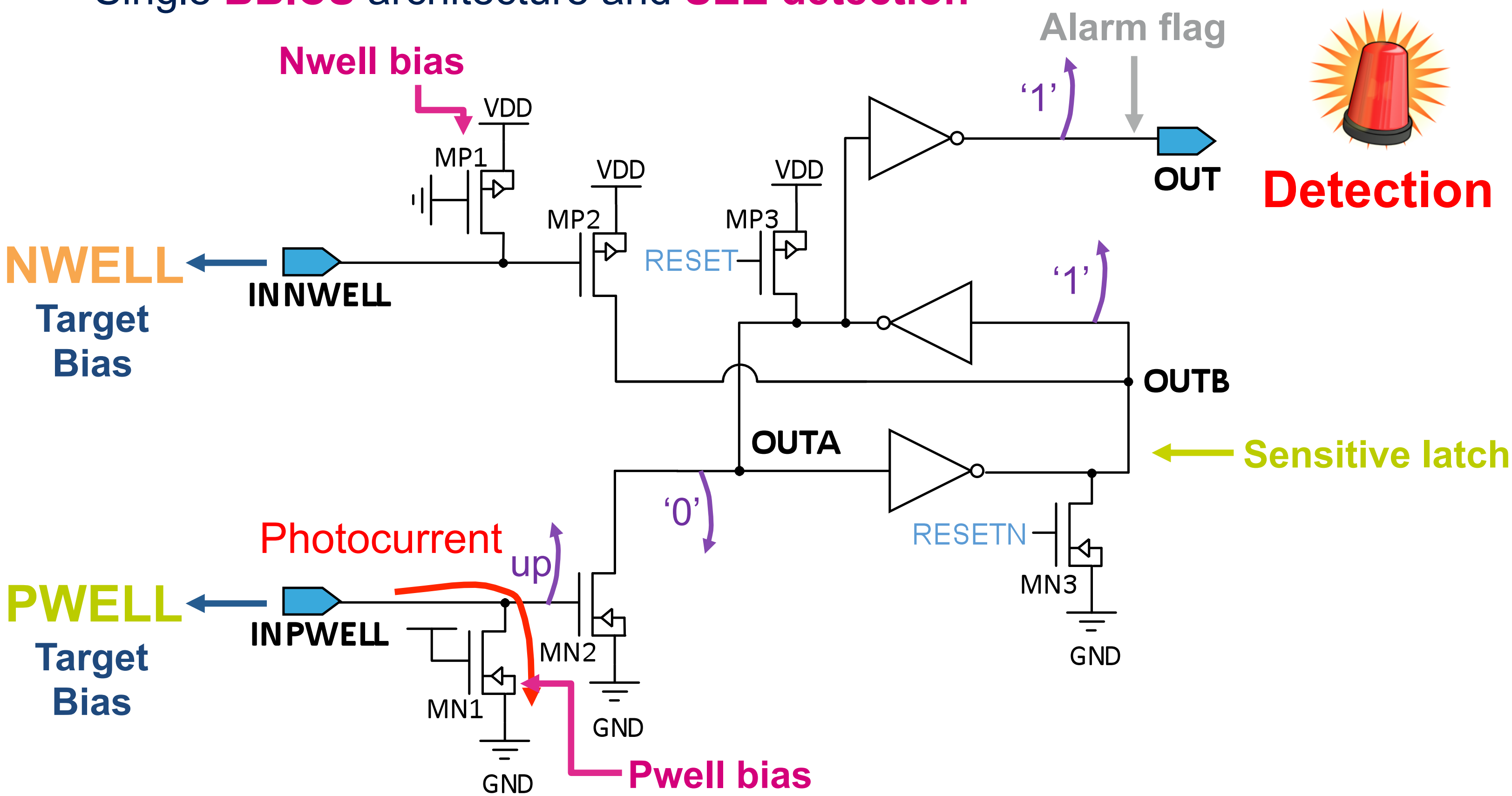
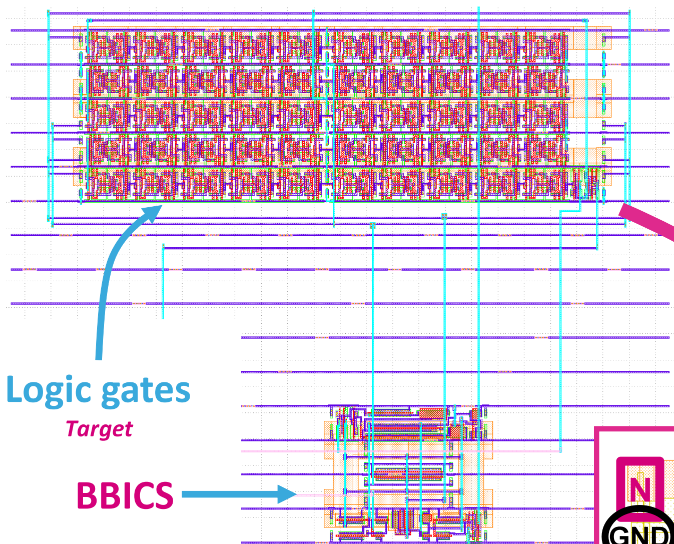
Architecture of the single BBICS used in experiments

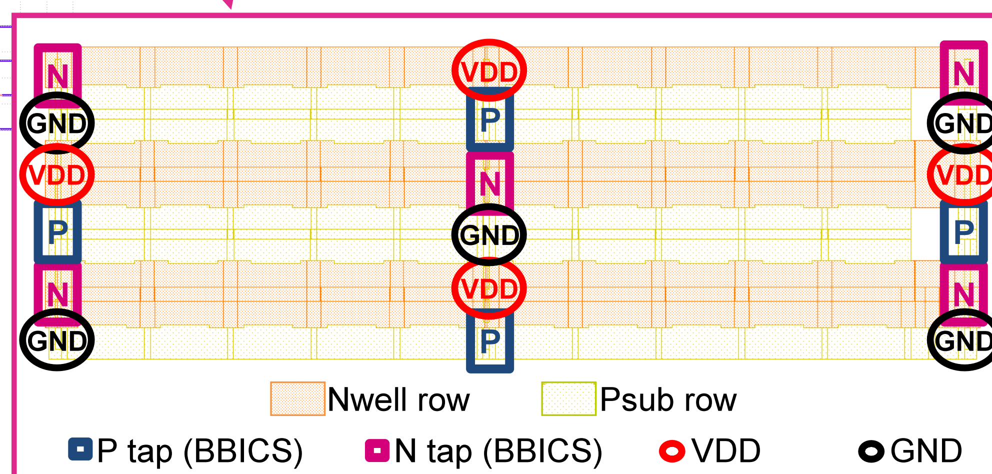
- Single **BBICS** architecture and **SEE detection**



Layout distribution and tapping



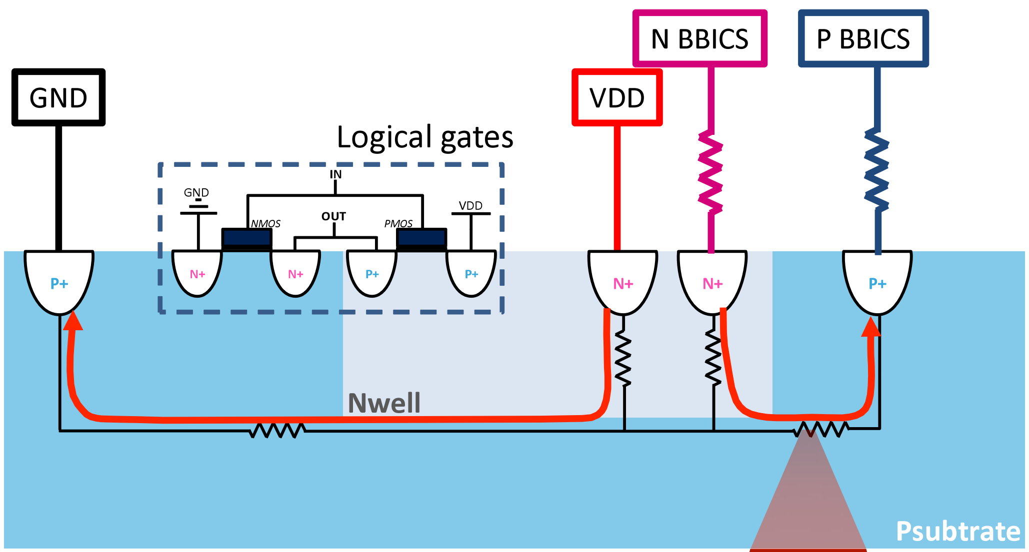
- Classical well tapping
  - Nwell tapping at **1.2V**
  - Psub tapping at **0V**
- BBICS well taping
  - **P taps** and **N taps**
- « Hybrid tapping » on target or 50%
  - **Merge** classical well tapping at power supply and BBICS tapping



- Target far from sensor
  - Avoid **perturbations** in the BBICS itself

Theoretical hypothesis

- Experimental hypothesis
  - Photocurrents flowing from VDD to GND may follow **two paths**
  - Photocurrent will **choose the less resistive path** depending on the position

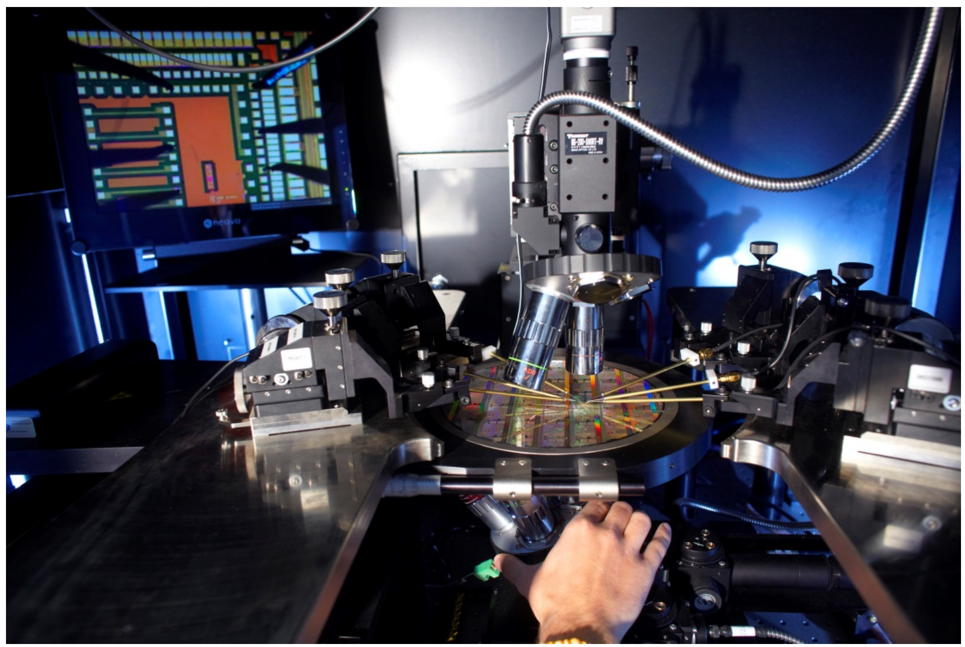


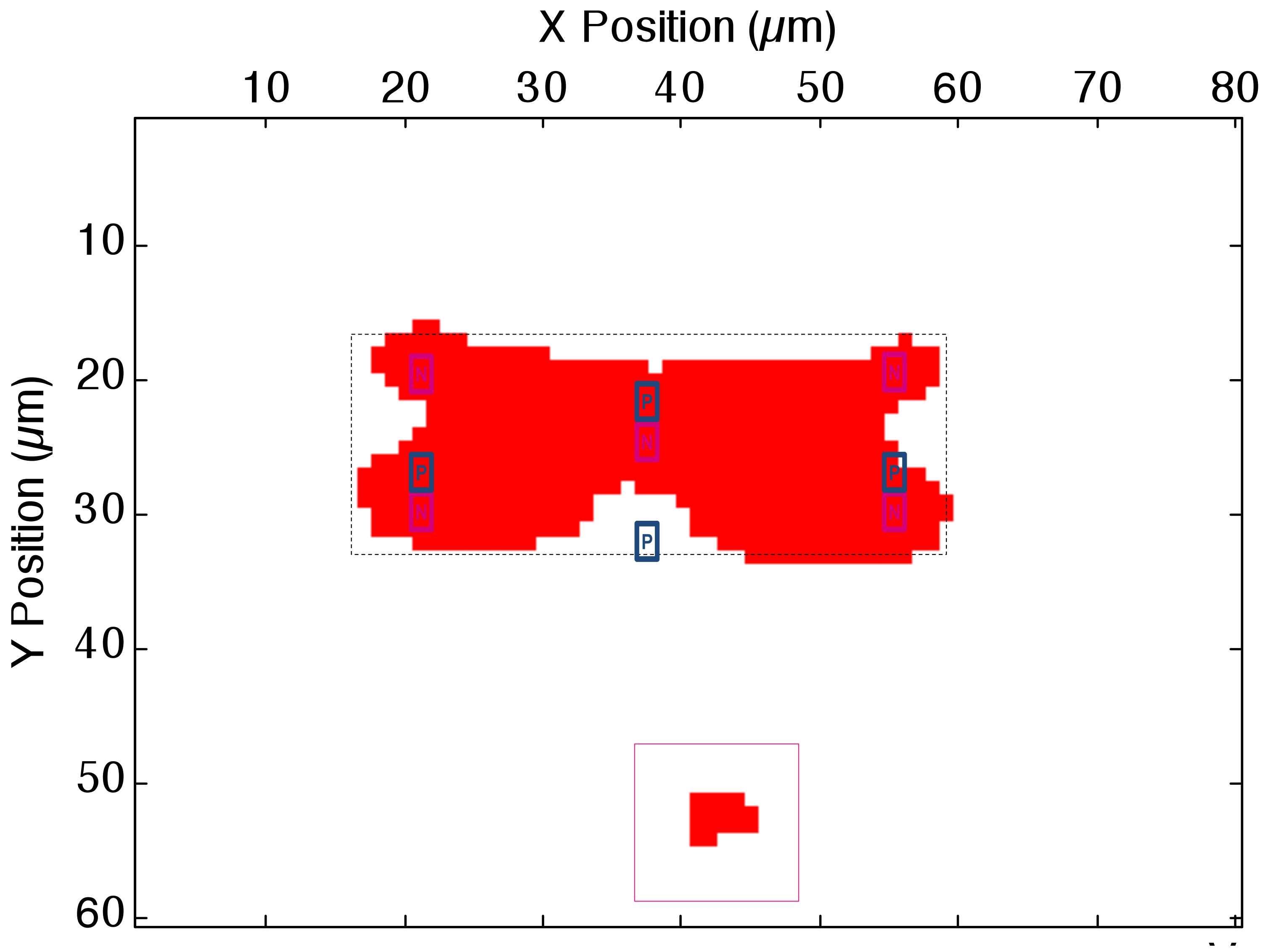
Resistors

VDD or GND **<** BBICS

- Less resistive […] **D/VDD path** compared to BBICS taps
- **No detection** […] VDD/GND

- Experimental set up
  - Wavelength: **1064 nm** (near Infra Red)
  - Spot size: **~ 1 µm**
  - Laser through silicon substrate **backside**
  - Laser power: **300 mW** and **250 mW**
  - Laser pulse duration: **200 ns**, **100 ns** and **50 ns**





X Position (μm)
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Y Position (μm)
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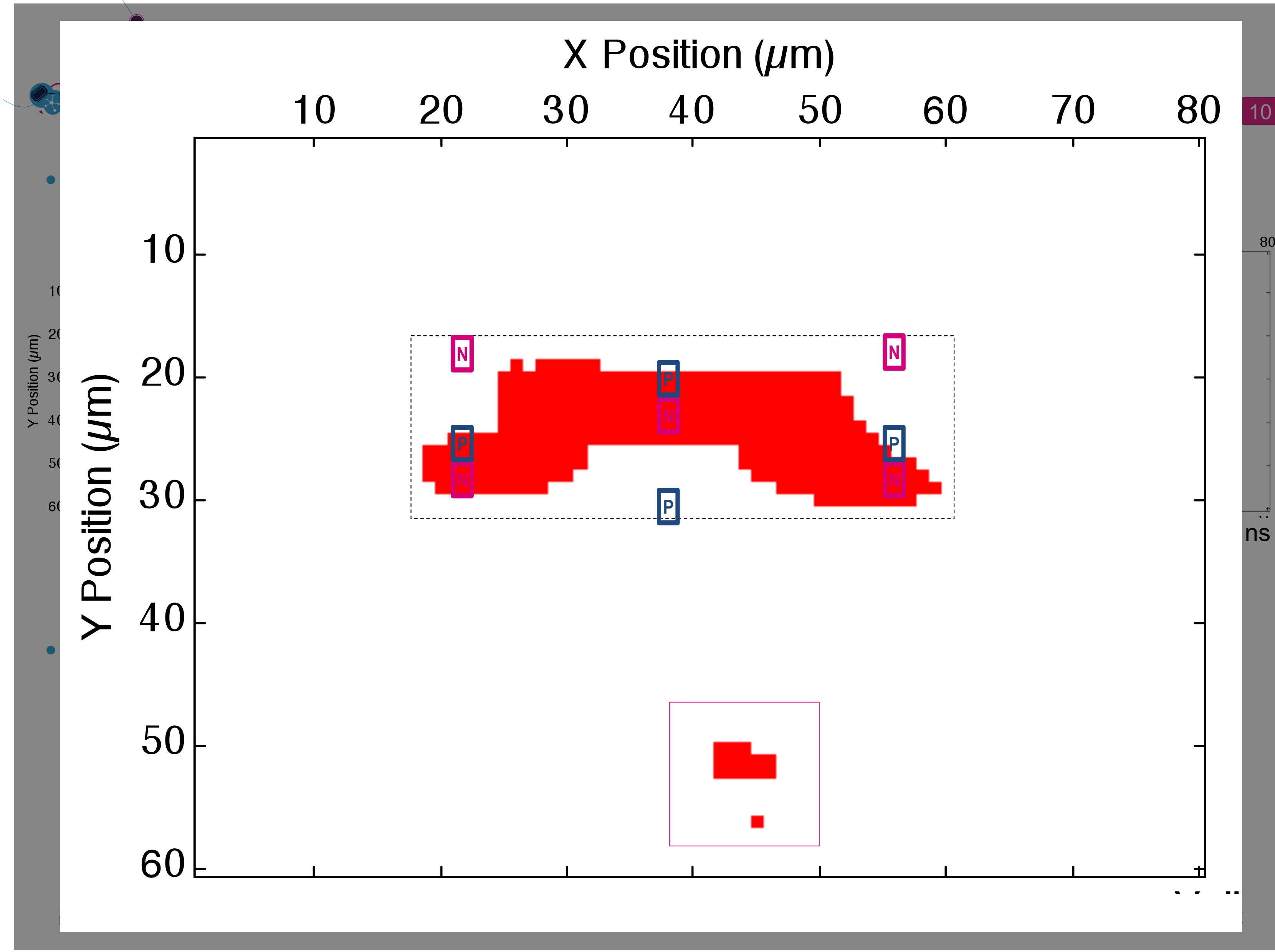
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Conclusion and perspectives

- The detection is **effective** for long laser pulse durations close to **N and P taps couples** but fail for short pulses duration
- **Detection effective** close to **BBICS taps couples**
- **No detection everywhere** because of the **hybrid tapping**
  - The classical biasing (VDD and GND) **hide** the BBICS detection
- Perspectives and future works
  - **New BBICS** will be designed and tested to validate other tapping (**100% BBICS taps**)

Thank you for your attention

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